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Donald D. Cox
Biology Department
State University College at Oswego

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ABSTRACT

Pollen diagrams were constructed for three stations in north central New York State and correlations with previous diagrams were made. A late-glacial phase of the diagram at Crusoe Lake was suggested and tentatively correlated with Deevey's L zones in Maine. Zone L1 was characterized by low spruce, high pine, and high NAP. Zone L2 was identified by a drop in pine and NAP with a rise in spruce and zone L3 by the return of pine and NAP with a drop in spruce. These were interpreted as representing cold to warmer to cold climatic oscillations associated with pre-Valders ice retreat, Two Creeks interstadial, and Valders ice advance. Postglacial zones A1, A2, and A3 were recognized by a high NAP frequency, a spruce peak, and a fir peak respectively. The Boreal Pine zone was identified at site II, but was missing from the truncated site III profile and was missing or greatly abbreviated at site I. The C zones were similar to those identified by other workers for central New York State: A *Tsuga* peak with rising *Fagus* and high *Quercus* in C1; a *Tsuga* minimum and a *Carya* maximum in C2; a return to *Tsuga* in C3. Subzones C2a, C2b, and C2c were suggested by an older *Tsuga* minimum, a secondary rise in *Tsuga,* and a younger minimum respectively. A correlation with a Late Middle Woodland Indian culture was attempted.

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[1] Manuscript submitted for publication November 4, 1964

[2] Biology Department, State University College at Oswego

Introduction

The present study was undertaken to reconstruct vegetational and climatic events through late-glacial and postglacial time to the present and to correlate this information with the archeology of the region under investigation.

Pollen analysis, as a research method, particularly lends itself to the accomplishment of the first part of this objective. It is felt that a high degree of success was achieved in this phase of the work. The second part, however, offered more of a challenge to palynological methods and its realization was much less certain. Particular attention was given to the possible detection of concentrations of *Zea* (corn or maize) and other Indian food plant pollens at points in the profiles. Further, attempts were made to recover pollen from soil samples taken from an archeological trench at an Indian campsite. Neither of these procedures proved entirely successful. No *Zea* pollen was identified in any of the profiles of the present study. It was hoped that if the Indians who occupied the sites surrounding the sample area had ever practiced the cultivation of corn, this would be reflected in the pollen profile. Soil samples taken by William A. Ritchie and Harold Secor from a trench near the Savannah site were processed for pollen content. The intent here was to get a pollen count that could be correlated with some level in the pollen profiles. These efforts were successful to a degree, but the results are far from conclusive.

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FIGURE 1. Location of pollen sampling sites ● and archeological sites ▲ in the Crusoe Lake area.

LOCATION AND DESCRIPTION OF SITES

Samples were taken from three sites in the southeastern corner of Wayne County in north central New York State (figure 1). According to a recent map of Wisconsin glaciation published by the Geological Society of America (Flint et al, 1959), the maximum advance of the most recent ice expansion in New York State reached a point about 10 miles south of the stations sampled in this study. Impounding, following the retreat of this expansion, resulted in the formation of an extensive glacial lake (Lake Iroquois?). The GSA map shows the southern shore of this lake to be several miles north of the area presently under consideration. The flora and very interesting history of this region are given in a comprehensive work by Wiegand and Eames (1925). Information regarding the physiographic history of the area is given by Fairchild (1934).

Crusoe Lake (Site I). Crusoe Lake is the most westerly of the three sample areas (figure 1). It is a very shallow lake in which the water depth varies from 1.0 to 0.5 meters in winter and spring to none at all in late summer. It is about 1.5 miles northwest of the town of Savannah lying in a depression mostly below the 380-foot contour line and completely surrounded by swampy lowland. The lake is oriented in a north-south direction, with a length of about 1 mile and a width of about one-fifth of a mile. On the east and west margins of the lake the belt of lowland is rather narrow, but north and south it extends several miles converging with the Montezuma Marsh to the south. A small stream, Butler Creek, flows into Crusoe Lake from the north and the lake is drained by Crusoe Creek, which flows into the Seneca River. The Seneca River is a meandering drainage which swings abruptly to the east at the study area, eventually joining the Oswego River to flow into Lake Ontario.

Bordering the lake for a variable distance averaging about 200 yards, is an elm-ash-maple swamp forest. Along the margin of the water the most conspicuous genera are *Typha, Decodon,* and *Lythrum.* A list of vascular plants along the lake margin and in the nearby woods (swamp forest), identified in the field by Stanley J. Smith, Curator of Botany, New York State Museum, is given below. Those species found in abundance are indicated by an asterisk.

Acer rubrum L. subsp. *rubrum**
Arisaema triphyllum (L.) Schott subsp. *triphyllum*
Bidens sp. (cf. *B. frondosa* L.)
Boehmeria cylindrica (L.) Sw. var. *cylindrica*
Carex crinita Lam.
Carex cristatella Britton

Carex lupulina Muhl.
Carex pseudocyperus L.
Carex retrorsa Schwein.
Carex stipata Muhl. var. *stipata*
Cicuta bulbifera L.
Cinna arundinacea L.
Circaea quadrisulcata (Maxim) Franch. & Sav. var. *canadensis* (L.) Hara
Cuscuta gronovii Willd.
Decodon verticillatus (L.) Ell.*
Dryopteris spinulosa (O. F. Müll.) Watt subsp. *spinulosa*
Eleocharis acicularis (L.) R. & S.
Elymus virginicus L. var. *virginicus*
Fraxinus americana L. subsp. *americana*
Fraxinus pennsylvanica Marsh. subsp. *pennsylvanica,* including var. *lanceolata* (Borkh.) Sarg.*
Fraxinus nigra Marsh.
Glyceria striata (Lam.) Hitchc. subsp. *striata*
Ilex verticillata (L.) Gray
Iris versicolor L.
Lemna minor L.
Lindera benzoin (L.) Blume var. *benzoin*
Ludwigia palustris (L.) Ell. var. *americana* (DC.) Fern. & Grisc.
Lythrum salicaria L.
Matteuccia struthiopteris (L.) Todaro var. *pensylvanica* (Willd.) Morton
Onoclea sensibilis L.*
Osmunda cinnamomea L.
Osmunda regalis L. var. *spectabilis* (Willd.) Gray*
Parthenocissus quinquefolia (L.) Planch.
Peltandra virginica (L.) Kunth
Penthorum sedoides L.
Polygonum coccineum Muhl.
Rhus toxicodendron L. subsp. *radicans* (L.) Clausen*
Ribes americanum Mill.
Rubus pubescens Raf.
Rumex verticillatus L.
Sagittaria latifolia Willd.
Saururus cernuus L.*
Smilacina stellata (L.) Desf.
Symplocarpus foetidus (L.) Nutt.
Thalictrum pubescens Pursh*
Thelypteris palustris Schott var. *pubescens* (Lawson) Fern.*

Ulmus americana L.*
Viburnum dentatum L. var. *lucidum* Ait.
Viburnum lentago L.

Samples from Crusoe Lake were taken at the south end of the lake at about one-third of the distance between the south and north ends and approximately in the middle, measured from east to west.

Savannah (Site II). The Savannah site is about four-fifths of a mile east of Crusoe Lake and 1.5 miles north of the town of Savannah on N.Y. Route 414 (figure 1). The samples were taken in a depression bordering the stream, near a bridge where the road crosses Crusoe Creek. Nearby, to the north and south of the creek, above the 380-foot contour level, are cultivated fields. The wooded areas in the vicinity are similar to those around Crusoe Lake.

Bluff Point (Site III). Bluff Point is slightly south and about 2.2 miles east of the town of Savannah (figure 1). It is almost opposite the place where Crusoe Creek joins the Seneca River. An island of hard ground rising above the 380-foot contour line, Bluff Point is completely surrounded by low marshy ground. At the time samples were taken, this marsh was covered with extensive stands of cattail (*Typha angustifolia* and *T. latifolia*) and reed canary grass (*Phalaris arundinacea*).

Samples were taken about one-fourth of the way between Bluff Point and Hickory Hill, near a man-made channel linking the Barge Canal with the channel of the Seneca River. On either side of the channel near the sample area is a stand of cattail that is about 20 yards wide. Between the *Typha* border and the hard ground of Bluff Point is a very dense zone of reed canary grass. This almost pure stand of grass extends to within 10 or 15 yards of the *Typha* stand; then it begins to thin out, and a number of other species are found in a zone between the *Phalaris* and the *Typha*. It was in this transition zone that samples were taken for pollen analysis.

METHODS

Field Technique. A Hiller peat sampler was used to collect samples at intervals of 10 centimeters. At Crusoe Lake, the sampling was done through about 0.5 meters of water from a floating platform constructed by lashing two boats together with two-by-fours. This gave the structure stability and formed a satisfactory platform from which to work. Samples were taken through the space between the boats in alternate holes about 1 meter apart. The alternate hole type of sampling was used at the Bluff Point and Savannah sites also.

In removing the peat from the chamber of the sampler, the surface peat was scraped away and a few grams for analysis taken from inside the core. Each sample was wrapped in aluminum foil and placed in a pint polyethylene bag with a label inside. Later, in the laboratory, these samples were transferred to labeled glass vials and stored in 30 percent alcohol.

The Hiller sampler used for this study takes a core 50 cm. long and about 2.5 cm. in diameter. After the five samples for analysis had been removed from each 50 cm. core, the remainder of the core was placed in a polyethylene bag to be inspected for seeds, shells, etc. The entire column extended to a depth of 11.7 meters at Crusoe Lake, 3.47 meters at Savannah, and 7.2 meters at Bluff Point.

Two cores were taken from the Savannah station. Site IIA provided a core to a depth of 2.63 meters where boulders were encountered. The sampler was moved downstream about 5 meters and a core (site IIB) was taken from 2.5 to 3.47 meters. At this point boulders were again encountered, after passing through a layer of blue clay.

Laboratory Technique. Those samples with a high mineral content were placed in HF for 24 hours, followed by heating to the boiling point. After rinsing in HCl and distilled water, the sediments were boiled in 5 percent KOH and acetolyzed. The residue was mounted in glycerin jelly prestained with either crystal violet or basic fuchsin. The sediments which did not contain appreciable amounts of mineral matter were treated similarly with the omission of HF.

A minimum of 150 tree pollens were counted, except where a scarcity of pollen on the slide made this impossible. The count was made using a binocular microscope with a calibrated mechanical stage. Most of the counts were made at 440X with occasional shifts to oil immersion, and the number of sweeps necessary for the minimum count was recorded. Later, the same number of sweeps was made using a similar type of microscope and only the nonarboreal pollen identified and recorded. Percentages presented here are based on the total pollen count, excluding aquatics and spores of ferns and mosses, except at site III where high grass counts made this method impractical.

In the zones of high *Pinus* occurrence in the profile, as the pine was identified its size was recorded. Where possible, the grains were measured from wing base to wing base and recorded in two categories: those under 50 microns and those larger.

ANALYSES AND STRATIGRAPHY

Crusoe Lake (Site I). The Crusoe Lake profile (figure 2) begins at 11.8 meters and extends with one break to 0.5 meters. The 0.5 meter level records the depth of the water at the time the samples were taken. There can be little doubt that the profile represents most of the postglacial record and it is believed to have late-glacial implications also. The profile begins with a very strong representation of pine and a smaller amount of spruce, with low maxima represented in the oak and birch curves. *Pinus* drops away rapidly above 11.7 meters and *Picea* advances to a maximum at 11.4 meters where *Pinus* is at a minimum. Accompanying this, the *Quercus* and *Betula* percentages show decreases.

From 11.4 to 11.0 meters, *Picea* drops to a minimum, while *Pinus* is rising to a second maximum. At this point, *Betula* shows a sharp advance, but *Quercus* continues at a low level.

Between 11.0 and 8.4 meters, *Picea* and *Pinus* undergo a series of complementary fluctuations, with *Picea* reaching a second maximum and *Pinus* a second minimum. *Betula* continues sporadically, but *Quercus* maintains a higher level than before with more constancy until it drops to a very low level as the *Pinus* minimum is approached. In the upper two-thirds of this zone, *Larix, Tsuga,* and *Abies* make their appearance.

Above 8.4 meters, *Pinus* rises to a third prominent maximum, subsequent to a very low *Abies* maximum while *Picea* is declining. Shortly above this *Pinus* peak, there are noticeably sharp increases in *Abies, Tsuga, Fagus,* and *Quercus.*

Tsuga continues to rise and reaches a peak at 5.6 meters that is maintained, with some fluctuation, to 5.1 meters. Between these points, *Fagus* rises constantly, and *Quercus* falls to a minimum. *Pinus* drops to a relatively low percentage while the broad-leaved genera are well represented between these levels.

At 5.1 meters, *Tsuga* begins to fall away suddenly to a minimum at 4.4 meters, then rises to a medium percentage and descends to a second minimum at 1.4 meters. Corresponding with these two minima, *Fagus* and *Quercus* rise to maxima. In both cases, the maximum is separated by a depression that agrees with the intermediate rise of *Tsuga*. *Pinus* maintains a steady low level and rises to a low peak coincident with the second *Tsuga* minimum. The *Carya* curve shows a maximal rise corresponding with the end of the hemlock intermediate advance.

Above 1.4 meters, the *Tsuga* curve rises to a second major peak near the surface. *Fagus* drops very noticeably in the surface layers, while *Quercus* declines only slightly from its maximum at the second hemlock depression. *Ulmus* and *Betula* are strongly represented in the surface layers.

Stratigraphically, the Crusoe Lake sediments are composed mostly of marly gyttja in the upper layers. From 0.5 to 1.3 meters, the sediments include an abundance of shells. Below this level, from 1.4 to about 4.8 meters, shells are much fewer. They become abundant again between 4.8 and 5.8 meters. The sediments at 7.7 meters consist of fine sandy clay which grades into blue clay at 8.7 meters. Blue to gray clay persists from this level to the bottom, where black streaks appear in the clay between 11.3 and 11.8 meters. Below this level, the sampler became so fouled that it refused to open.

Savannah (Site II). The Savannah profile (figure 4) is a composite formed from two different cores about 5 meters apart. Site IIA apparently takes up where site IIB leaves off, with very little overlapping.

The profile begins at the bottom of IIB with a strong component of pine and spruce accompanied by smaller quantities of oak, birch, and fir. Between 3.47 and 2.80 meters *Picea* drops to a very low level white *Pinus, Abies, Betula,* and *Quercus* undergo significant increases. *Abies* increases to a maximum as *Picea* drops and *Pinus* increases to a very high constant level.

By the time the *Abies* maximum begins to drop at 2.6 meters, *Quercus* and *Betula* have become firmly established and other broad-leaved genera are represented.

The IIA profile begins at this point, and the first noticeable change is an important rise in *Pinus* to a prominent maximum at 1.8 meters. *Pinus* starts to decline above 1.8 meters and *Quercus* rises to an important maximum. *Tsuga* starts a rise at the *Pinus* peak which culminates in a maximum at 0.8 meters and continues to the surface. The oak decreases as hemlock rises, and in the surface levels oak is moderately represented. *Pinus* is strongly represented in the surface levels of the profile, along with *Acer* and *Tilia.*

Below 3.37 meters, site II stratigraphy consists of clay overlying boulders at 3.47 meters. Above the former level is marl, which extends to the 1.2 meter level. At 1.2 meters marl gives way to light brown organic sediment, which grades into dark brown peat at 0.7 meters. From 0.4 meters to the surface the core consists of black muck.

Bluff Point (Site III). The Bluff Point profile (figure 5) begins at 7.2 meters with what appears to be a pine-hemlock forest in which the broad-leaved genera, especially oak and beech, are well established. There is a sudden change in hemlock frequency at 6.0 meters as it drops to a low level with pine, beech, and oak showing increases. This is the beginning of a long interval of low *Tsuga* percentages which ends at 1.1 meters. Above this level, *Tsuga* again rises to a position of prominence in the profile. From the 6.0 to the 1.2 meter level, *Pinus* and *Quercus* are the most important components of the profile, with *Fagus, Carya,* and *Ulmus* strongly represented. Beginning at 0.7 meters *Pinus* increases to a position of importance at the surface, while *Fagus, Carya, Ulmus,* and most of the other broad-leaved genera show decreases. *Quercus, Tsuga,* and *Pinus* are very prominent in the surface layer.

The first 0.3 meters at Bluff Point consist of very soft muck. Below this level varying shades of fine brown peat persist to 6.4 meters. At this level, marly clay begins and extends to 7.2 meters, interspersed with three distinct layers of shells between 6.9 and 7.2 meters. Below this, the sediments were so firm that further penetration by the sampler was impossible.

DISCUSSION

Crusoe Lake is the most complete profile presented here, and two interpretations of its lower $1\frac{1}{2}$ meters are possible. The profile may represent only postglacial time or the bottom levels may reflect late-glacial climatic oscillations. If the former interpretation is accepted, the diagram shows an unusually long spruce-pine zone. This does not necessarily mean a proportionately long interval of time but may be the result of rapid accumulation of sediments.

Postglacial Interpretation. There are two recognizable vegetative fluctuations below the 9.7 meter level. Between 11.7 and 11.3 meters there is a *Picea* maximum accompanied by minima in *Pinus* and nonarboreal pollen. This has been designated zone L2 (figures 2 and 3), and it may represent the original invasion by vegetation following the retreat of the Valders ice. Between 11.2 and 10.2 meters, there are a series of *Pinus* and NAP maxima and a *Picea* minimum which have been designated zone L3. The high incidence of nonarboreal pollen (figure 3) suggests an open vegetation. Zone L3 may reflect a cooling trend brought on by an oscillation in the melt-back of the ice front and characterized by a more or less open vegetation with spruce and pine growing on favorable sites. For reasons which will be discussed later, the pine curve may not be reliable in this zone. The interpretation of the profile from the 10.1 meter level to the surface is the same whether one considers the bottom levels postglacial or late-glacial.

Late-Glacial Interpretation. If a late-glacial phase is assumed, zones L2 and L3 can be correlated with late-glacial zones that have been identified for other parts of eastern North America. Most of the identifiable herbaceous pollen in the lower $1\frac{1}{2}$ meters of the profile are *Gramineae* and *Cyperaceae* (figure 3). Deevey (1951) used these as indicators of open vegetation in his original identification of late-glacial pollen zones in Maine. Deevey, however, found much higher percentages of NAP than were identified in the present study. More recent papers by Andersen (1954), Martin (1958), Livingstone and Livingstone (1958), Ogden (1959), and Frey (1959) indicate that smaller percentages of herbaceous pollen may have late-glacial significance. It should be recognized, however, that AP/NAP ratios without the identification of specific open-vegetation indicators are to be accepted with great reservations.

Three possible late-glacial zones have been tentatively identified at Crusoe Lake. The 11.8 and 11.7 meter levels show herbaceous and pine pollen increasing, with spruce declining. This may represent the retreat of a pre-Valders ice front. The *Picea* peak with the *Pinus* and NAP minima in zone L2 can be interpreted as indicative of a warming trend which allowed spruce to become established in the area. The spruce curve depression in zone L3 accompanied by high percentages of NAP may be taken to represent a return to colder conditions.

The behavior of pine in these zones is not easy to explain. Pollen size-frequency data show that it is all large-grained. This suggests *Pinus strobus* or *P. resinosa*. It is hard to imagine either of these species growing under park-tundra conditions. There are several possibilities that will explain the presence of large pine pollen in this part of the profile. In the first place, it may be the result of expansion during the KOH and acetolysis treatments. Livingstone and Livingstone (1958) report similar difficulties. Secondly, it may represent redeposition from older deposits. Andersen (1954), Martin (1958), Livingstone and Livingstone (1958), Davis (1961), and others have reported instances of this phenomenon in late-glacial deposits in North America. Also, long distance transport by wind of the pollen of *P. strobus* or *P. resinosa* could explain their presence in Crusoe Lake deposits. Any combination of these may have occurred, so that little significance can be attached to the pine curve in these zones.

A hesitant correlation with Deevey's (1951) L zones in Maine is suggested here. His L1 and L3 cold zones, characterized by high NAP and low spruce, compare well with zones L1 and L3 respectively at Crusoe Lake. Deevey's "Aroostook Oscillation" or L2 with a lower herbaceous count and higher percentages of *Picea* and *Betula* in Maine correlates with zone L2 at site I.

Deevey (1951) suggested that all of his L zones in Maine represent tundra, the arboreal pollen being the result of long distance transport by wind. Livingstone and Livingstone (1958) have suggested that their L1 and L3 zones may have been characterized by " scattered patches of trees." The NAP percentages at Crusoe Lake, though not so high as in Maine and Nova Scotia, favor an open vegetation during L1 and L3 times. These zones are similar to one another in showing high NAP and *Pinus* with low *Picea.* Whether or not they represent actual climatic and vegetational changes, the pine and spruce oscillations certainly appear to be zone markers in the profile. The L1 and L3 zones at Crusoe Lake differ in the higher proportion of *Betula* and herbaceous pollen in L3 than in L1. L2 is characterized by a maximum in *Picea* and minima in *Pinus, Cyperaceae, Ambrosia,* and other composites. This is evidence for a less open vegetation during L2 times with a higher incidence of spruce. If the L zones in the Crusoe Lake profile do represent late-glacial time, it is not probable that the vegetation in the surrounding area was of the type that Polunin (1961, p. 382) describes as high, low, or middle arctic tundra. It may have more closely resembled the " taiga " he describes (p. 346).

The occurrence of up to 8 percent of *Quercus* in the L zones of the diagram is anomalous. No species of oak in North America today has an arctic distribution. Pollen of this genus, however, has been identified repeatedly in late-glacial pollen zones. Andersen (1954), Martin (1958), and Livingstone and Livingstone (1958) have concluded that in their samples this is the result of redeposition. Deevey (1951) is of the opinion that it was windblown from a great distance. Davis (1958) contends that the oak pollen in these zones of her diagram came from plants growing in the vicinity. The area of her study was probably 200 or more miles south of the Valders maximum advance, so it seems likely that she has given a valid explanation. Our present interpretation places the Crusoe Lake site much closer to the ice front, and we believe that oak in the vicinity does not seem likely. The lack of organic matter in the sediments of the L zones at Crusoe Lake tends to support this hypothesis. Small numbers of *Acer, Fraxinus,* and *Ulmus* were identified with *Quercus* in these zones. As Fries (1962) has suggested, a climate warm enough for these genera to grow in the vicinity should have produced a greater quantity of micro- and macro-organisms in the lake than there is evidence of in the sediments. There is the possibility that the pollen of these temperate deciduous trees was deposited as the result of long distance transport by wind. However, the probable anticyclonic circulation of cold air away from the ice front (Dillon, 1956) offers a hazard to this hypothesis. These genera disappeared from the profile shortly after the postulated invasion of postglacial spruce. This could represent merely a change in relative abundance, or the pollen may be rebedded and its drop marks the end of solifluction and slope wash following the retreat of the Valders ice front.

It is possible that during the deposition of the deepest sediments at Crusoe Lake the whole area was covered by an extensive body of water, bordered on the north by the southern margin of the glacier. Many of the herbaceous indicators of tundra are entomophilous and those which are not are often low growing and thus less subject to pollen transport by wind. These considerations and the possible outflowing of cold air from the glacier may explain the low absolute pollen frequency and the low NAP percentages in the bottom levels at Crusoe Lake.

It should not be overlooked that the bottom sediments (at Crusoe Lake) could have been the result of rafting from the nearby ice front. This would explain some of the erratic fluctuations in the pollen curves at these levels. At this writing, there is no clear evidence that rafting did occur. In the light of such evidence, the profile for the lower four meters would have to be reexamined with much less confidence in the pollen zones identified here.

In the absence of radiocarbon dates, it is impossible to decide with certainty whether the bottom $1\frac{1}{2}$ meters at site I represent late-glacial or early postglacial time. If this represents late-glacial time, it becomes apparent that the Valders readvance of the Wisconsin ice did not cover the area included in this study. However, the accumulation of more data is necessary in order to settle this important question conclusively.

Above the zone identified as L3, the nonarboreal pollen drops to around 10 percent, accompanied by an increase in spruce and a decrease in pine. Following Deevey's (1951) interpretation, this is accepted as marking the development of postglacial closed spruce forests in the area.

Zone A. The postglacial spruce zone has been widely recognized in eastern North American profiles and given the designation A by Deevey (1939). This usage will be followed in the present paper. A1 at Crusoe Lake is characterized by the appearance of *Larix*, with a minor increase in *Betula* and relatively high values for *Gramineae* and *Cyperaceae*. The continuing presence of possibly rebedded pollen of deciduous species, especially oak, may indicate that a considerable amount of slope wash resulting from an incomplete cover of vegetation was still going on. A2 shows a maximum of 66 percent for *Picea* and a corresponding drop in *Pinus*. The herbaceous pollen falls to about 10 percent and oak disappears completely from the diagram. This may signify a complete closure of the vegetational cover and a decrease in erosion and redeposition. The presence of *Abies* and *Tsuga* in A2 is associated with a probable increase in moisture and temperature during this time. The A3 zone is very weakly represented at Crusoe Lake but more strongly at site IIB. At both stations, it is characterized by maxima in the *Betula* and *Abies* curves.

Zone B. The pine zone is very doubtfully indicated at site I but well shown at IIA. At site IIA, it is accompanied by a sharp drop in *Betula* and a minor maximum in *Quercus*. The sediment column from site I is interrupted at this point by a water pocket which extends through 1.5 meters to the 5.8 meter level. This probably accounts for the very short pine period and may represent an unconformity. If this is the case, the hiatus appears to be of short duration as the profile recommences at 5.9 meters in early C1 time.

Above the pine zone at site IIA, the diagram is untrustworthy. The rise of *Tsuga* may indicate the beginning of C1 time or there may be an unconformity between 1.8 and 1.0 meters, with the top meter representing C3 time. The increase in *Picea* is evidence for the latter, while the increase in *Quercus* at the 1.6 meter level supports the former. If the C1 zone is present, the profile is truncated at the top with C2 and C3 missing. If there is an unconformity, zones C1 and C2 are missing. Evidence from an archeological trench, which will be discussed later, lends a strong argument for the latter hypothesis.

Samples of the water between 7.6 and 5.8 meters at site I were brought up in the Hiller sampler and stored in plastic bags. The water from the middle of the pocket contained no pollen but countable numbers were found in the upper and lower samples. This is probably the result of contamination from the sediments that enclose the pocket above and below. The increase in *Gramineae* and *Cyperaceae* below, and of *Ambrosia* above, however, cannot be explained so easily. Comparison with the surface sample suggests a solution to the problem, as the surface level shows high percentages of the same pollen types. The water pocket may be contaminated by seepage from the open water in the lake.

Zone C. The C zones are present in both the Bluff Point (site III) and the Crusoe Lake (site I) profiles. The two diagrams correlate very well in showing C1 and C3 characterized by pronounced *Tsuga* maxima and C2 by a *Tsuga* depression. These oscillations have been previously established in New York State by Deevey (1943), Sheldon (1952), Cox (1959), and Durkee (1960).

C1 at both stations is emphasized by a hemlock maximum with rising beech and strong representations of oak and other broad-leaved genera. The pine curve at Bluff Point is evidently the result of a local disturbance. The normal pine curve for this section of the diagram in central New York State is probably more accurately described by the Crusoe Lake pine curve.

The C2 zone at site I is complicated by a minor readvance of *Tsuga,* set off by two *Tsuga* minima. Pollen spectra presented by Cox (1959), Durkee (1960), and Brown (personal communication) point to the possibility that this is a regional oscillation rather than a local disturbance. There is evidence at Crusoe Lake for three C2 sub-zones, tentatively identified as C2a, C2b, and C2c.

C2a is recognized by a hemlock minimum with a beech maximum. Smaller advances in *Quercus* and *Nyssa* are present, coincident with a peak in *Cyperaceae. Tsuga* readvances in C2b as *Carya* attains a maximum and *Fagus* a minimum. In C2c, *Tsuga* again falls to a minimum, while *Fagus* is rising to a lower peak and *Quercus* to a higher peak than in C2a. Apparently C2 time was characterized by two periods of relative dryness separated by an interval when there was more available moisture. The high *Fagus* percentages in C2a and the strong occurrence of *Quercus* in C2c suggest drier climatic conditions in the latter than in the former. The rise in pine and sedge pollen in C2c is further evidence for this interpretation. The *Carya* peak that occurs in C2b comes at the end of the period, and *Carya* continues at relatively high percentages until early C3 time. Cox (1959) has given reasons for accepting the hypothesis that the vegetative fluctuations characterizing C2 time in central New York were the result of temperature changes only. The data presented here do not justify a more elaborate interpretation.

These subzones are less pronounced in the Bluff Point histogram for possibly two reasons: (1) the disturbance created by the pine pollen curve and (2) the elongated profile representing C2 time. A rapid accumulation of sediments is undoubtedly responsible for the latter. According to Deevey and Flint (1957), C2 time lasted for about 3,000 years. During this time, 3.8 meters of sediments accumulated at site I and 4.8 meters at site III. The sediment columns for C1 and C3 are of approximately equal lengths at the two stations.

Hemlock rises to a second major peak marking the end of C2 and the beginning of C3 at both Bluff Point and Crusoe Lake. *Quercus* continues at a high level, but *Fagus* falls off sharply in the surface levels. *Picea* reappears at site III. In most of the pollen profiles that have been constructed for New York State, the *Tsuga* maximum in C1 is greater than in C3. *Picea* is virtually absent from C1 but is characteristic of C3. If the C3 spruce is accepted as indicative of climatic change, the higher *Tsuga* count and the absence of *Picea* in C1 is strong evidence for a warmer and more moist climate than in C3.

Some components of the NAP curve at site III are of considerable interest. The most pronounced feature is the sudden jump of grass from zero in the basal clay to conspicuous values which are maintained to the top. Within this part of the curve, grass represents as much as 57 percent of the total pollen. As the grass pollen was identified it was measured and its size recorded (figure 6). Most of it in the upper 1.8 meters compared favorably in size with the pollen of *Phalaris arundinacea,* which is presently abundant in the area. If it is assumed that the grass pollen in the upper 1.8 meters of sediment is *Phalaris,* it seems that, except for changes in water depth, conditions in the vicinity of site III may have been much the same since late C2 time with spring flooding and marshy summer savannahs.

Carbon 14 Dates. In the summer of 1959, after the pollen diagram had been constructed, samples for radiocarbon dating were taken from Crusoe Lake using the multiple-shot technique with the Hiller sampler. Pollen counts were made above and below the levels to be dated to confirm their place in the profile. The depths chosen were the beginning and the end of the C2 period at 5.0 and 1.3 meters respectively, as indicated by the pollen curve. The former was dated at 6850±150 (I220) and the latter at 3200±100 (I219) years before the present. Both of these dates are over a thousand years too old to represent the limits of C2 time suggested by Deevey and Flint (1957). It is not impossible that these dates mark the limits of C2 time in central New York State, but it seems improbable. There is no other evidence to support so great a disagreement with other sections of eastern United States, but to our knowledge there are no other radiocarbon datings of pollen zones from this region of the State. The evidence at this time, however, favors contamination of the dated samples with carbon from an older source. An error of this magnitude could result from the assimilation by living organisms of carbon from older carbonates. Since we have been unable to specifically identify any other source of contamination, this hypothesis for the deviation in the above dates is tentatively accepted here.

Indian Cultures. The location of the area for the present study was chosen in view of the many prehistoric Indian sites in this vicinity as reported by Harold Secor (personal communication). These sites, scattered over a rather wide geographical area, share the common feature of occurring along the 380-foot contour line (figure 1).

Ritchie (1951a) has described the Archaic Lamoka Indian culture in New York State and has given a radiocarbon date for it of about 3500 B.C. This is about the middle of the hypsithermal period of Deevey and Flint (1957) and about the end of the C1 period as it occurred in south-central New England. The above date would probably fall in the upper third of the first hemlock zone in New York State as set forth by Cox (1959). The forests there during this interval probably consisted largely of *Tsuga* and *Fagus*, with *Quercus* occurring on the south-facing slopes and ridges.

The Indian campsites involved in the present study are believed to reflect a more recent culture than the one mentioned above. On November 19, 1959, an archeological test pit was excavated by Ritchie and Secor about 10 feet from the point where the site IIA sediment column was taken. As the pit deepened, samples were collected at and below levels which held evidence for the presence of man. A summary of the notes taken by Ritchie for each of the seven samples is given below:

Sample 1. Depth 8 inches from surface. Crumbling Indian pottery found with this sample.

Sample 2. Depth 9–10 inches. Taken just over layer of deer bones, many broken for marrow extraction. No artifacts found with bone on this level.

Sample 3. Depth 12 inches. Sample taken among deer bones. One rude, stemmed, flint point or knife and one flint and scraper found among bones.

Sample 4. Depth 13 inches. Taken immediately below bone layer. Scattered deer bones still present at this depth, and below to 15 inches from surface.

Sample 5. Depth 15 inches. The random scatter of deer bones disappeared below this depth, as did all other evidence of the presence of man.

Sample 6. Depth 19–20 inches. To this depth the soil appeared black and granular, like woods mould or rotted duff. At this level occurred a thin, compact, lenticular stratum which appeared to us to resemble matted bark or more probably reeds and other marsh vegetation. This sample was taken off the top of this matted layer, directly in contact with it.

Sample 7. Depth 22 inches. At this level a reddish layer, apparently of limonite or bog iron, c. 1 inch thick, was present throughout the excavation, which was now beginning to fill with water.

Below this horizon, to the maximum depth excavated, i.e., 3 feet, the material appeared to be a uniform peat. All of this deposit was below the current water level.

Later, after examining the material in the laboratory, Ritchie writes (personal communication):

> The flint point found at the 12 inch level, being a discard of manufacture, has little diagnostic value, as is also the case with the end scraper found at the same depth.
>
> The potsherd from the upper level yields, however, some helpful information, concerning its cultural and temporal provenience. It consists of a body sherd measuring 2 x 3 inches, cord-malleated on the exterior and faintly straited or channeled on the interior. It is grit tempered and sandy in texture, and has a crude " plat " of corded impressions by way of decoration over the corded surface, i.e. a cord-on-cord treatment. It appears to fit into the Vinette 2 ware group (Ritchie and MacNeish, 1949) of the late Middle Woodland period and to be of Point Peninsula 2 cultural provenience (Ritchie, 1951b). Although not yet radiocarbon dated in the area, this culture probably flourished between about A.D. 500–700.

A pollen profile was constructed from these sediments (figure 7), using the same methods which were described earlier. The diagram indicates a clear correlation with the top meter of the site IIA profile. If the Indians who left their traces here, were in fact, more recent than the Archaic Lamoka Indians, the profile leaves little doubt that they were of C3 time.

A large lake extending into the Montezuma Marsh and having the 380-foot contour as its approximate shoreline is suggested by the many Indian campsites along this line. These camps were probably fishing camps and not contemporaneous. According to Ritchie (personal communication), "a wide range of ages is obvious in these sites — several thousand years!" This lake, then, of which Crusoe Lake is but a remnant, was probably older than C3 time and may have persisted until well after A.D. 500. Figure 7 indicates that during the time the campsite was being used, the surrounding forest consisted of hemlock, pine, and hardwoods, among which oak, maple, and basswood were important.

Summary*

The present study has yielded a vegetational history for the Crusoe Lake area that probably began 10,000 to 12,000 years ago. It is impossible to say whether the Two Creeks interstadial period is represented in the pollen diagram. In any case, the ice front must have been fairly close and the climate severe in this area during the deposition of the bottom $1\frac{1}{2}$ meters. The arboreal vegetation seems to have consisted mainly of spruce and pine with an occasional fir. These probably grew on the more protected sites, with grasses and sedges interspersed with other herbaceous species, partially covering the open spaces.

Apparently, the ice retreated and a closed spruce-pine-fir forest became established before 7500 B.C. The spruce-pine-fir forest seems to have been replaced by one in which pine dominated between 7500 and 6500 B.C. While this forest is not well represented in the Crusoe Lake profile, it has been established in central New York State by other studies. The climatic changes which brought it about were probably an increase in temperature and a decrease in available moisture.

Beginning about 6500 B.C., the first postglacial deciduous forests probably began to establish themselves in central New York State. This was the result of a further increase in temperature, accompanied by an increase in moisture, so that during this period the climate may have been warmer and more moist than it is today. The most important forest trees were probably hemlock in the coves and on the north slopes, with oak occurring on the ridges and south slopes. There is evidence that elm and maple were also well represented in the forest, with beech and hickory beginning to come in toward the end of the period. Archaic Lamoka Indians probably invaded central New York about the end of this interval. The major forest trees during this invasion seem to have been hemlock and oak.

* The dates given in this summary are based on radiocarbon dates given by Deevey and Flint (1957), Deevey (1958), and Ritchie (1957).

Beginning about 3000 B.C. and extending to about 2,000 years ago, was an interval of time during which there was less available moisture than either the period preceding or following it. Based on the pollen record, the most noticeable change in the forests of central New York State was a decrease in the amount of hemlock. Beech probably replaced much of the hemlock on the more moist sites, with oak and hickory abundant on the drier locations. The latter part of this interval may have been drier than the first, as evidenced by the smaller amount of beech and greater proportion of oak. There is evidence for an interval in the middle of this period when available moisture increased.

During the past 2,000 years, there are indications of a decrease in temperature accompanied by an increase in the moisture available to plants. Pollen statistics suggest that the forests during this time were somewhat similar to those which persisted in the interval following the pine period. The earlier interval was probably the warmer of the two and the later one dryer. In both periods, hemlock seems to have been the most abundant forest tree in central New York State. Late Middle Woodland Indians probably flourished in the area around Crusoe Lake during the early part of the most recent climatic interval from A.D. 500 to 700. At this time, a large lake, of which Crusoe Lake is a remnant, may have occupied this basin extending into the Montezuma Marsh. Many Indian campsites, along the 380-foot contour line, suggest fishing camps along the shoreline. These campsites are not contemporaneous but appear to represent a spread in time of several thousand years. This suggests that the lake persisted, at least periodically, from late hypsithermal time to A.D. 700 or later.

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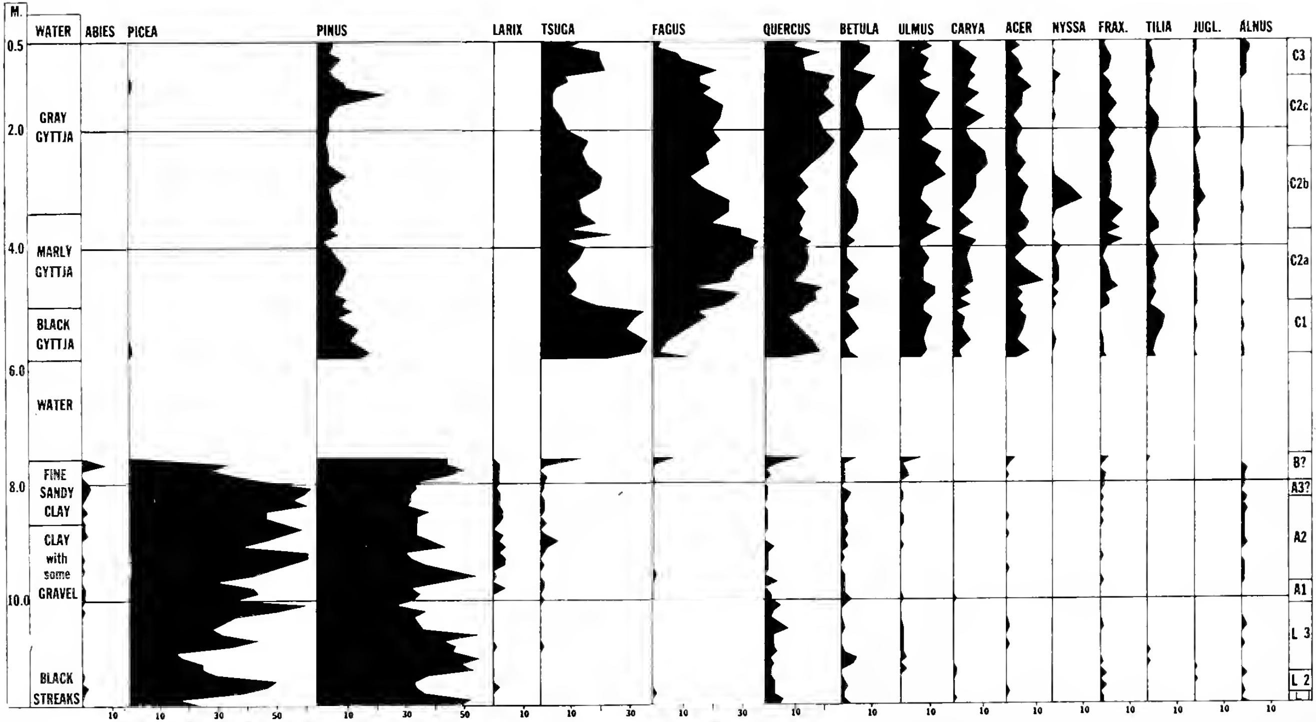


FIGURE 2. Arboreal pollen diagram at site I, Crusoe Lake.

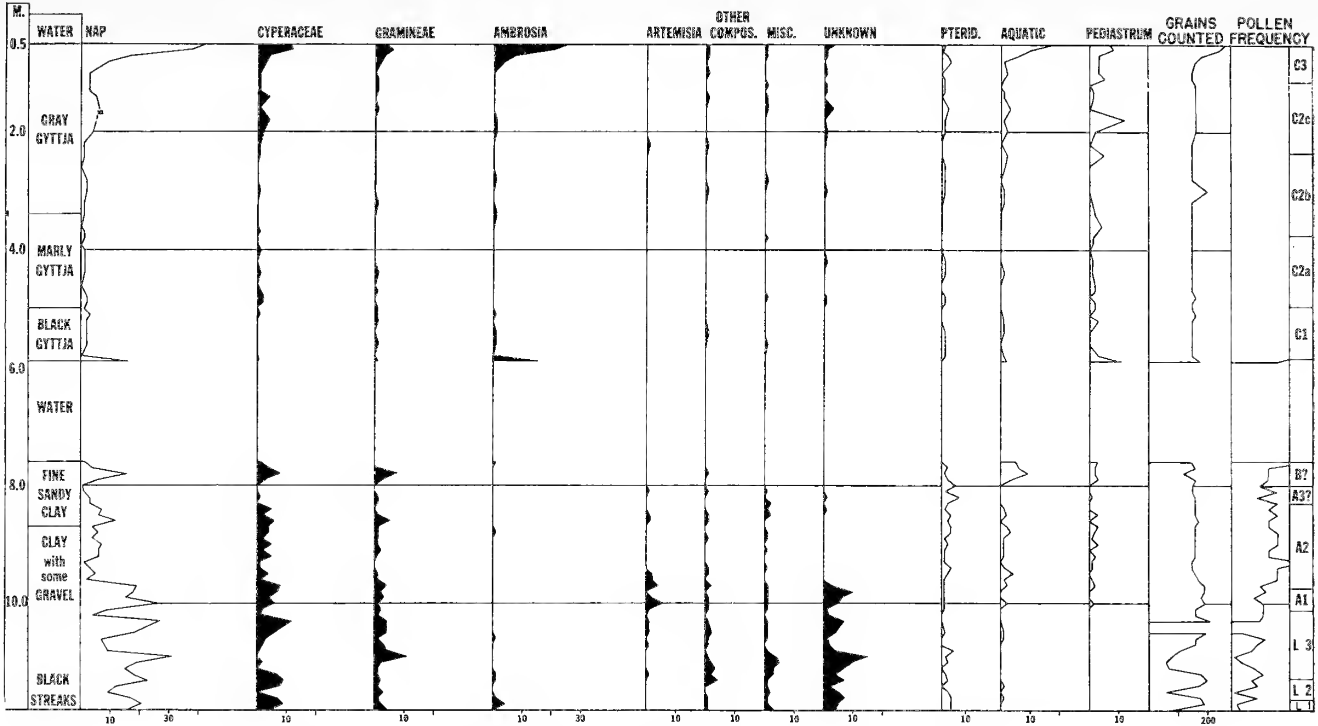


FIGURE 3. Nonarboreal pollen diagram at site I, Crusoe Lake.

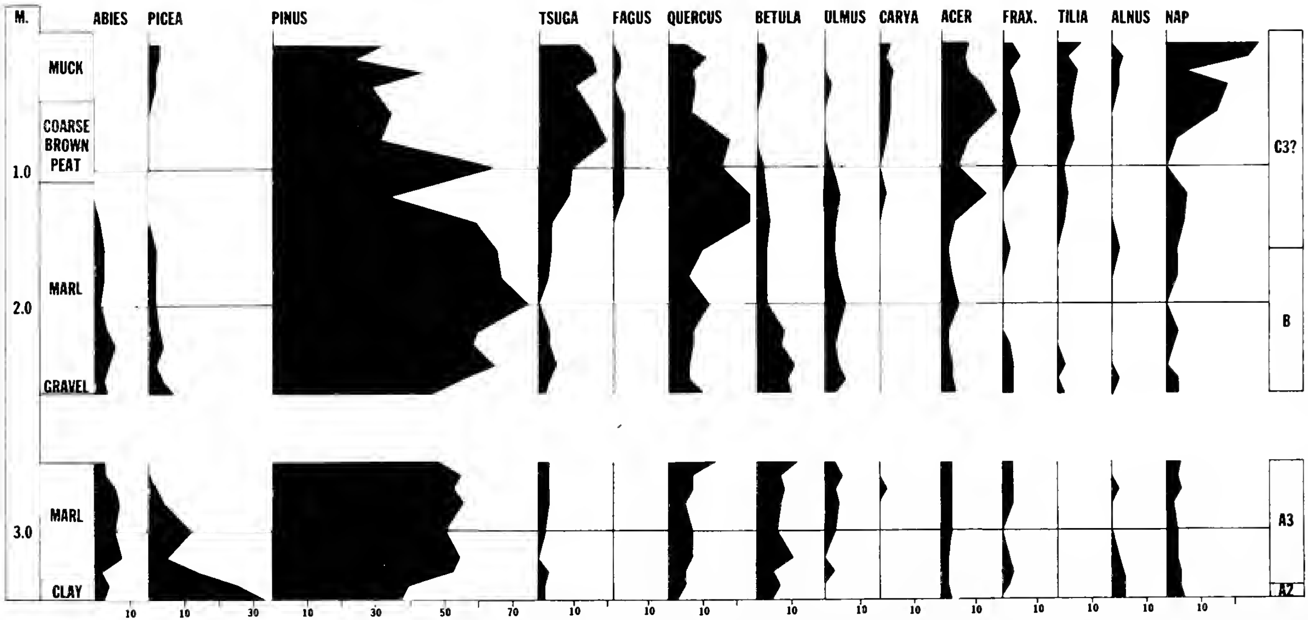
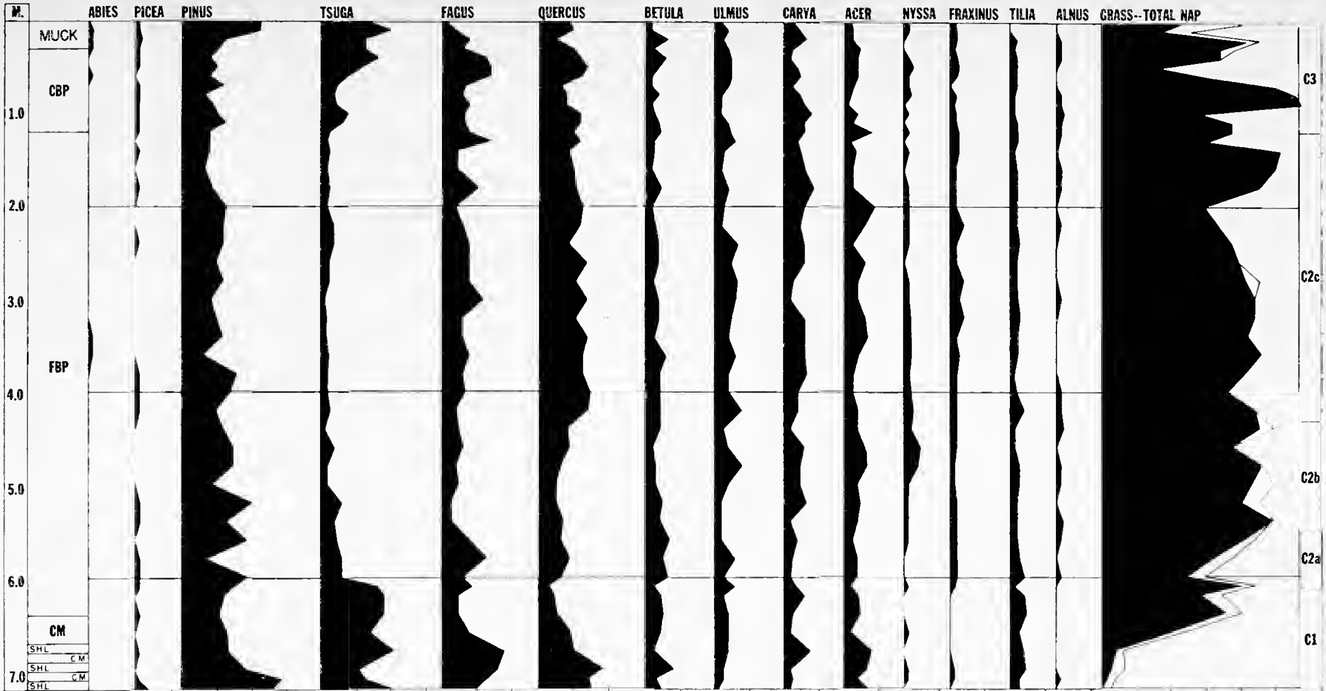


FIGURE 4. Pollen diagram at sites IIA and IIB, Savannah.



CBP -- COARSE BROWN PEAT
FBP -- FINE BROWN PEAT
CM -- CLAY MARL
SHL -- SHELL LAYER

Fig 5 Pollen profile at Site III, Bluff Point. Percentages based on total arboreal pollen except for the grass-total NAP curves which are based on total pollen excluding aquatics and ferns.

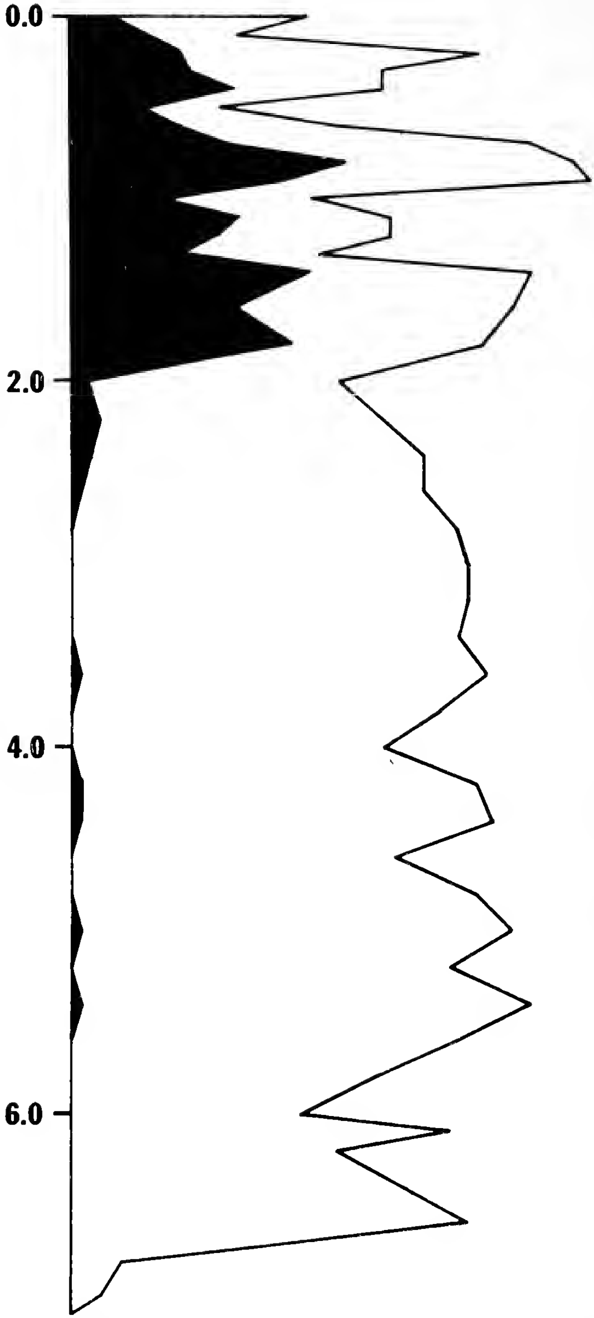


FIGURE 6. Curves showing grass pollen greater than 40 microns and total grass pollen at site III.

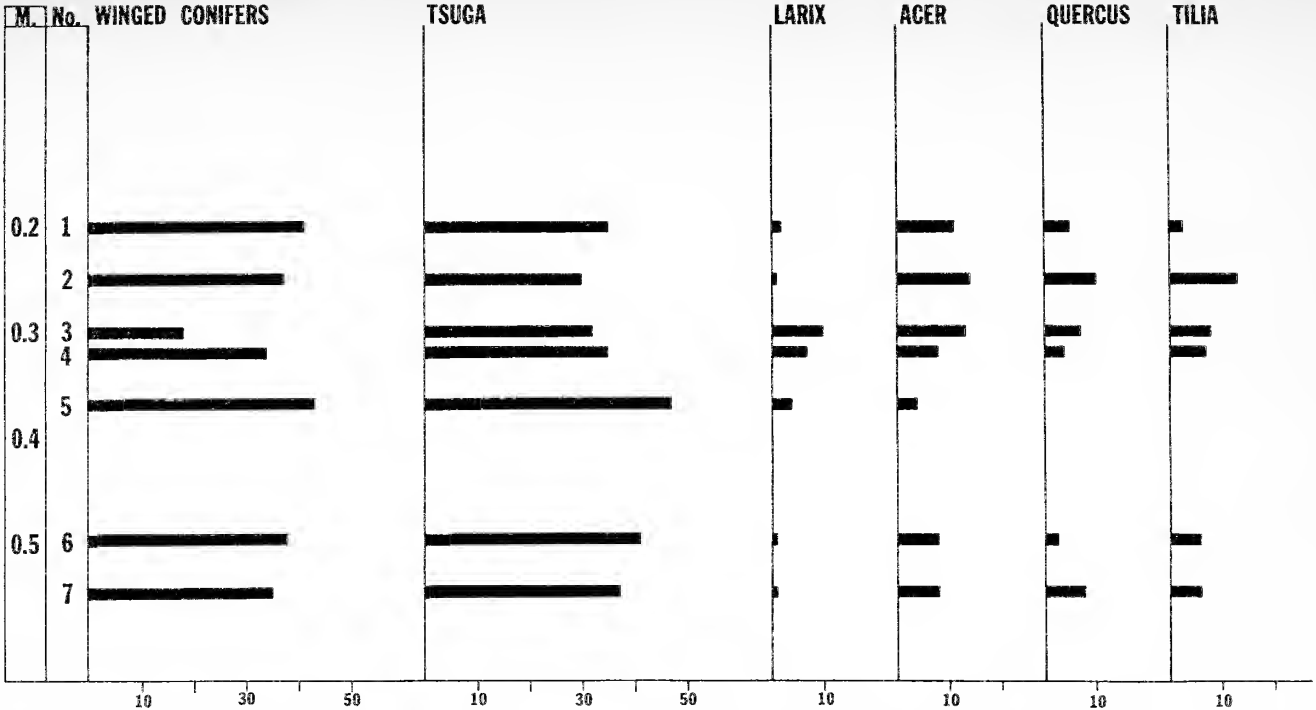


FIGURE 7. Pollen diagram constructed from the seven samples taken from the archeological test pit at site II. Percentages based on total arboreal pollen.